More details/abstract: Forest degradation in West Africa is generally thought to have negative consequences on rural livelihoods but there is little overview of its effects in the region because the importance of forests to rural livelihoods has never been adequately quantified. Based on data from 1014 rural households across Burkina Faso and Ghana this paper attempts to fill this knowledge gap. We demonstrate that agricultural lands and the non-forest environment including parklands are considerably more valuable to poor as well as more well-off rural households than forests. Furthermore, product types supplied by the non-forest environment are almost identical with those from forests. Accordingly, forest clearance/degradation is profitable for and, hence, probably performed by rural people at large. We attribute rural people's high reliance on non-forest versus forest resources to the two countries' restrictive and inequitable forest policies which must be reformed to promote effective forest conservation, e.g., to mitigate climate change..

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Deforestation and the limited contribution of forests to rural livelihoods in West Africa: Evidence from Burkina Faso and Ghana

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Corresponding Author:	Marième Pouliot, MSc University of Copenhagen Frederiksberg, DENMARK
Corresponding Author Secondary Information:	
Corresponding Author's Institution:	University of Copenhagen
Corresponding Author's Secondary Institution:	
First Author:	Marième Pouliot, MSc
First Author Secondary Information:	
All Authors:	Marième Pouliot, MSc
	Thorsten Treue, PhD
	Beatrice Obiri-Darko, PhD
	Boureima Ouedraogo, PhD
All Authors Secondary Information:	
Abstract:	Land cover change studies in Ghana and Burkina Faso document forest clearing/degradation in all agro-ecological zones. This is generally thought to have negative consequences on rural livelihoods, particularly for the rural poor. Yet, based on data from 1014 households across the two countries we demonstrate that agricultural lands and non-forest environment are considerably more valuable to rural livelihoods than forests. Furthermore, product types supplied by the environment outside forests are almost identical with those from forests. Hence, forest clearance/degradation is profitable for and probably performed by rural people. We attribute rural people's high reliance on non-forest vs. forest resources to the two countries' restrictive and inequitable forest policies which must be reformed to promote effective forest conservation. Our research sites fall within land cover types accounting for almost 75% of West Africa's area with some tree/scrub cover and share demographic, deforestation and forest policy characteristics with most West African countries.
Suggested Reviewers:	Kojo Amanor, PhD Professor, University of Ghana kojoamanor@gmail.com His main research interests are in the land question, smallholder agriculture, forestry policy, environment and rural development in Ghana.
	Freerk Wiersum, PhD Associate Professor, Wageningen University freerk.wiersum@wur.nl His research interests include the role of forestry in rural development. He has worked with questions of land use change in Africa, including a comparison of the value of forests vs non-forest environmental lands.

	Jesse Ribot, PhD Associate Professor, University of Illinois ribot@illinois.edu He conducts research on decentralization and democratic local government, natural resource tenure and access and household vulnerability in the face of climate and environmental change.

FOREST & LANDSCAPE

Danish Centre for Forest,
Landscape and Planning

University of Copenhagen
Rolighedsvej 23
DK-1958 Frederiksberg
Tel: +45 3533 1500

Editor-in-Chief Bo Söderström
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E-mail mapo@life.ku.dk
Tel +45 5011 6366

Cover Letter

We are hereby submitting our manuscript entitled "Deforestation and the limited contribution of forests to rural livelihoods in West Africa: Evidence from Burkina Faso and Ghana". Our manuscript falls into the "Report (Original Research)" category. Main text contains 5730 words.

Based on detailed income data collected quarterly during 2007/08 from 1014 rural households across Burkina Faso and Ghana, we demonstrate that, contrarily to what could be hypothesized based on the existing literature, forests are of limited importance to rural households. We show that agricultural lands and the non-forest environment are considerably more valuable to rural livelihoods than forests. Hence, we argue that forest clearance/degradation is profitable for and probably performed by rural people. Through literature studies, we document deforestation and forest degradation trends in Ghana and Burkina Faso and relate these results to similar data on sub-Saharan West Africa. Furthermore, we attribute rural people's high reliance on non-forest vs. forest resources to the two countries' restrictive and inequitable forest policies, which must be reformed to promote effective forest conservation as intended in the on-going REDD+ processes.

We hereby declare that this manuscript is our original work, that it is not being submitted elsewhere and that all appropriate codes of ethics were followed during the research.

Sincerely,

Marième Pouliot
Doctoral candidate
Danish Centre for Forest, Landscape and Planning
University of Copenhagen
mapo@life.ku.dk

Mariève Pouliot is a doctoral candidate at the Danish Centre for Forest, Landscape and Planning, University of Copenhagen, Denmark. Her research focuses on forests and livelihoods, including the link between forests and human health, in West Africa.
Danish Centre for Forest, Landscape and Planning, University of Copenhagen, Rolighedsvej 23, 1958 Frederiksberg, Denmark. Tel: +45 3533 1500. Fax: +45 3533 1508.

Thorsten Treue is an Associate Professor at the Danish Centre for Forest, Landscape and Planning, University of Copenhagen, Denmark. His research generally focuses on forest governance and particularly on the socioeconomic, bio-physical and democratization effects/outcomes of decentralized forest management in developing countries.
Danish Centre for Forest, Landscape and Planning, University of Copenhagen, Rolighedsvej 23, 1958 Frederiksberg, Denmark.

Beatrice Darko Obiri is a research scientist at the Forestry Research Institute of Ghana, Ghana. Her research focuses on forest product markets, farming systems, sustainable land use, ethnobotany, agricultural ecological economics, livelihoods and gender analyses in Ghana.
Forestry Research Institute of Ghana, P. O. Box UP 63 KNUST, Kumasi, Ghana.

Boureima Ouedraogo is an Associate Professor at the Département de Sociologie, Université de Ouagadougou, Burkina Faso. His research focuses on the sociology of development and on the links between poverty and the environment in Burkina Faso.
Département de Sociologie, Université de Ouagadougou, 03 B.P. 7021, Ouagadougou 03, Burkina Faso.

Deforestation and the limited contribution of forests to rural livelihoods in West Africa: Evidence from Burkina Faso and Ghana

Marième Pouliot, Doctoral candidate, Danish Centre for Forest, Landscape and Planning, University of Copenhagen, Rolighedsvej 23, 1958 Frederiksberg, Denmark. Tel: +45 3533 1500. Fax: +45 3533 1508.

Thorsten Treue, Associate professor, PhD, Danish Centre for Forest, Landscape and Planning, University of Copenhagen, Rolighedsvej 23, 1958 Frederiksberg, Denmark.

Beatrice Darko Obiri, Research Scientist, PhD, Forestry Research Institute of Ghana, P. O. Box UP 63 KNUST, Kumasi, Ghana.

Boureima Ouedraogo, Associate professor, PhD, Département de Sociologie, Université de Ouagadougou, 03 B.P. 7021, Ouagadougou 03, Burkina Faso.

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Abstract

Land cover change studies in Ghana and Burkina Faso document forest clearing/degradation in all agro-ecological zones. This is generally thought to have negative consequences on rural livelihoods, particularly for the rural poor. Yet, based on data from 1014 households across the two countries we demonstrate that agricultural lands and non-forest environment are considerably more valuable to rural livelihoods than forests. Furthermore, product types supplied by the environment outside forests are almost identical with those from forests. Hence, forest clearance/degradation is profitable for and probably performed by rural people. We attribute rural people's high reliance on non-forest vs. forest resources to the two countries' restrictive and inequitable forest policies which must be reformed to promote effective forest conservation. Our research sites fall within land cover types accounting for almost 75% of West Africa's area with some tree/scrub cover and share demographic, deforestation and forest policy characteristics with most West African countries.

Keywords: Deforestation, West Africa, forest/environmental incomes, rural livelihoods, Burkina Faso, Ghana.

1. Introduction

There is a general consensus among policy-makers, researchers and development practitioners that environmental resources contribute to rural livelihoods in developing countries by supporting current consumption and providing households with a form of 'natural insurance' against hardships (e.g. Mamo et al. 2007). The literature abounds in evidence of forests and other environmental resources' contribution to household income in different regions around the world. In Africa, a study involving 7 countries across the continent has shown that the forestry sector plays a significant role in national economies, and that informal activities in the sector (fuelwood and non-timber forest product (NTFP) collection) contribute to household income and employment generation (Whiteman and Lebedys 2006). In the dry forests of South Africa, Shackleton et al. (2007) show that forest income represents around 20% of average total household income. The comprehensive study by Cavendish (2000) in Zimbabwe showed that 35% of average total household income (cash and subsistence) came from non-cultivated environmental goods. In Northern Nigeria, wild foods consumption and marketing forms an important coping strategy for rural populations (Harris and Salisu 2003). In Mali, NTFPs may be as important as cultivated crops for rural people, and 90% of the NTFPs are collected in natural forests (Gakou et al. 1994). Overall, the general wisdom is that forest dependence increases with decreasing income, i.e. forest income's share of total income is highest for the poorest households (e.g. Vedeld et al. 2004).

However, West African forests are generally being cleared or degraded as a result of evolving human utilization including the effects of climate change (e.g. Gonzalez 2001; IPCC 2007) (see also below). This environmental degradation is expected to affect rural livelihoods tremendously (Shackleton et al. 2011) – especially poor and marginalized households who are hypothesized to be

most dependent on environmental resources. Meanwhile, slowing down or reversing tropical deforestation and forest degradation to reduce greenhouse gas emissions from deforestation and forest degradation (REDD) remains a cornerstone in IPCC's recommendations to prevent an irreversible and potentially disastrous increase in global temperatures because this would 'buy' rich countries time to maintain their energy consumption (and hence living standards) while gradually inventing and switching to fossil free/neutral energy sources (IPCC 2007). Accordingly, it appears that rural people in poor countries and people in rich yet fossil fuel dependent nations are 'natural allies' because they share a common interest in conserving existing tropical forest resources. The political implications of how much rural people in poor countries rely on forest and non-forest environmental resources for their livelihoods should, however, be considered in the context of these people's ability to benefit from these resources whether or not they hold officially recognized rights to do so. If rural people do not hold meaningful and enforceable rights to benefit from forests, it is reasonable to expect that they would rather convert than conserve them, unless forests supply important products that cannot be substituted or accessed elsewhere.

We argue that at present there is little overview of the likely overall as well as distributive effects of continued forest degradation on rural livelihoods in the West African region because the users of forests and the importance of income from forest and other environmental resources to rural livelihoods have not been adequately quantified. Therefore, this paper aims at: (i) providing empirical evidence of the economic importance of forest and other environmental incomes to rural households in four areas of Burkina Faso and Ghana; and (ii) assessing the likely effects on rural livelihoods of continued forest degradation through a product-specific comparison of incomes that rural people derive from forests and non-forest environmental resources, respectively.

2. Materials and Methods

2.1 Study area and context

Figures 1 and 2 are adapted versions of the European Space Agency's GLOBCOVER interactive map source (ESA/GLOBCOVER 2008) and depict the land cover types in the sub-Saharan part of West Africa as well as the location of sites 1-4. Table 1 provides the map legend including the relative extent of land cover types.

Figure 1 goes about here

Figure 2 goes about here

As figures 1, 2 and Table 1 indicate, the sites in Burkina Faso (1 and 2) are located within areas dominated by three land cover types; (i) Closed to open (>15%) scrubland (<5m), (ii) Mosaic: Forest/Scrubland (50-70%)/Grassland (20-50%) and (iii) Rain fed croplands. Together, the land cover types within which sites 1 and 2 are located, account for 41.1% of the land area shown in figure 1. Site 3 in Ghana is located in the transition zone between high forest and savannah. This area is dominated by three land cover types; (i) Mosaic: Cropland, Tree cover and Natural Vegetation, (ii) Closed to open (>15%) evergreen and/semi-deciduous forest (>5m) and to a lesser extent (iii) Rain fed croplands. Site 4 is located within the wet-evergreen/semi-deciduous part of Ghana's high forest zone, of which most has been converted to farming purposes. The land cover is

dominated by two types; (i) Mosaic: Cropland, Tree cover and Natural Vegetation and (ii) Closed to open (>15%) evergreen and/semi-deciduous forest (>5m).

In total, sites 1-4 are located within land cover types that account for about 61.6% of the sub-Saharan land area in figure 1. Areas with no scrub or trees cover about 17.4% of the land. Accordingly, sites 1-4 fall within land cover types that account for almost 75% of land with some tree or scrub cover. Since West Africa is among the most densely populated areas on the continent (FAO 2008; Table 2), land cover types which include some tree and scrub cover must logically support the livelihoods of millions of rural people.

Burkina Faso is one of the poorest countries of the world: it ranked 181st of 187 countries in UNDP's human development index (UNDP 2011); more than half of the country's population (56.5%) lives on less than 1.25$/day (UNDP 2011) and the 2010 adult literacy rate was estimated at 28.7% (UNDP 2011). By contrast, Ghana is one of the better-off countries in sub-Saharan Africa: in 2010, it ranked 135th in the human development index and people living under 1.25$/day and the adult literacy rate were estimated at 30.0% and 66.6%, respectively (UNDP 2011).

Pouliot et al. (2008) and Obiri et al. (2011) offer detailed descriptions of the study sites. In summary, the basic characteristics are:

Site 1, 11°30' North and 00°58' West, is situated in the centre-south region of Burkina Faso. This region is one of poorest of Burkina Faso, as some 66% of the population lives below the national poverty line at 0.41USD/day. The climate is dry with annual rainfall ranging between 800 and 1000 mm in the region. This site is located on the main road between Ouagadougou (140 km) and the

Ghanaian border (60 km). The Nobéré site borders the nature reserve “Parc National Kaboré Tambi” where land cover consists mainly of open forest with patches of savannah. The park is an important source of fuelwood, fodder, food, construction materials, and medicines for local people’s subsistence. Outside the park, the land cover is mainly savannah, fallow and parklands. People in the area practice subsistence agriculture dominated by millet, sorghum, and to some extent maize. Agriculture is complemented with animal husbandry.

Site 2, 10°38'0" North and 4°54'0" West, is situated in the south-western part of Burkina Faso, Cascades region. This is one of the regions where the incidence of poverty is lowest, as some 39% of the population lives below the national poverty line. Annual rainfall ranges between 1000 and 1200 mm. It is the most forested region of the country and less disturbed forests can be found due to a relatively low population density. People in the area practice subsistence agriculture dominated by millet, sorghum, and maize, but commercial agriculture is also a common activity with sweet potato, yam, and cotton as the main crops. Agriculture is complemented with animal husbandry but to a lesser extent than in site 1.

Site 3 comprises 15 villages around 7°28’00’’ North and 1°50’00’’ West in Brong-Ahafo region, which covers the middle portion of Ghana. The villages lie in the transition between the high forest and the savannah zones where the annual rainfall is around 1100 mm. Three of the villages are situated in the vicinity of Boabeng-Fiema Monkey Sanctuary while the remaining 12 surround the connected and rather degraded (open canopy) forest reserves of Asubima and Afrensu-Brohuma. Combined subsistence and commercial agriculture is the main economic activity and products include maize, yam, vegetables, cassava, groundnut, cowpea, cocoyam, plantain, cashew, cotton and tobacco. Livestock rearing also forms part of many households’ activity portfolio. In Brong-

155 Ahafo, 29% of the population lives below the national poverty line of 1.00 USD/day which
156 coincides with the national average.
157
158 *Site 4* comprises 15 villages around 5°13'00'' North and 2°00'00' West in Ghana's Western
159 Region, which covers the South Western part of the country. The villages are situated in the mosaic
160 agricultural landscape between Nueng, Nueng South, Bonsa River and Subri River forest reserves
161 which belong to the tropical wet evergreen ecology zone that has an annual rainfall of around 2000
162 mm. Subsistence and commercial agriculture are the main occupations and products include cocoa,
163 palm oil, rubber, cassava, plantain and yam. Animal husbandry is extremely limited. The Western
164 Region is among the wealthiest in Ghana and 'only' 18% of the population lives below the national
165 poverty line.
166
167 *Deforestation and forest degradation*
168
169 FAO's 2010 forest resource assessment reports significant deforestation in Burkina Faso and Ghana
170 as well as in most other West African countries during the periods 1990-2000; 2000-2005 and
171 2005-2010 (Table 2).
172
173 **Table 2 goes about here**
174
175 Good quality empirical national-level data on the trends in forest and tree cover in Burkina Faso
176 and Ghana are not available (Westholm and Kokko 2011; Hansen et al. 2009), but a number of
177 satellite image-based land cover change studies in the two countries may serve to generally assess
178 the tree cover trends –and to verify/assess the FRA data presented in Table 2.

In the Sissili province of Burkina Faso, which lies immediately west of site 1, Ouedraogo et al. (2010) found a drastic reduction of dense forest land from 69.7% in 1986 to 31.4% in 2002 and 40.6% in 2006 (1.45% decrease per annum; 1986-2002). The Sissili Protected Forest went from 100% dense forest in 1986 to about 50% dense forest and 50% open woodland in 2006 and the total area of open woodlands within the province went from 22.8% in 1986 to 32.1% in 2006 (an average increase of 0.46% per annum). Yet, this latter land cover type has been spatially very dynamic with large areas going from dense forest to open woodland and back. During the period 1992-2002, open woodland went from 20% to 44%. In 2006, some areas had grown back into dense forest albeit in smaller patches than was the case in 1992. The coverage of cropland had steadily increased from 7.5% in 1986 to 26.6% in 2006. Wardell et al. (2003) arrive at largely similar results. In Maro reserve, immediately north of site 2, Idinoba et al. (2010) found that, during the period 1986-2002, riparian forest had decreased from 3,775 to 2,958 ha (0.17% decrease per annum), savannah woodland had decreased from 13,881 to 9,382 ha (0.25% decrease per annum) while scrub savannah had increased from 24,865 to 27,552 ha (0.08% increase per annum).

Accordingly, the general picture of land cover change in Southern Burkina Faso appears to be that larger areas of dense forest are converted to open woodland, rain fed cropland and smaller patches of dense forest. Ouedraogo et al. (2009) document a very strong correlation between forest degradation/deforestation/agricultural expansion and in-migration of people from northern Burkina Faso to the Sissili province where higher soil fertility and more rainfall offer better agricultural potentials. The drivers of this general north to south migration appear to be a combination of increasing population density and increasing aridity in the northern part of the country. For the period 1962-2006, Idinoba et al. (2010) document an increase in the mean annual temperature of

203 1.5°C and a 20 mm rainfall decrease in Burkina Faso. While urbanization is prominent in Burkina
204 Faso, the most common destination for domestic migrants from rural areas is in fact other rural
205 areas (Henry et al. 2004a). Migrants are moving from the northern and central regions to the
206 western and southern parts of the country (Sawadogo 2006), and decreasing rainfall appears to be a
207 strong determinant, which increases the likelihood of long-term migration to the southern and
208 western parts of the country (Henry et al. 2004b). The strong impact on forest cover of this
209 southward migration is believed to be clearance for agriculture amplified by newcomers' tendency
210 to also produce charcoal and firewood for cash such that they can buy food until their first crop
211 matures (Ouedraogo et al. 2009).
212
213 Idinoba et al. (2010) show that within Wenchi district in Ghana's transition zone (immediately west
214 of site 3), open forest went from 32% in 1972 to only 5% land coverage in 2000 (1.2% reduction
215 per annum) and closed savannah woodland went from 59.4% to 21.2%. In the high forest zone
216 district of Wassa Armani, which is immediately north-west of site 4, they found that closed forest
217 coverage went from 57.6% in 1985 to 34.2% in 2000, moderately closed tree cover (>15 trees/ha)
218 went from 7.2% in 1972 to 5.9% in 2000 while moderately open forest (<15 trees/ha) increased
219 from 35.0% in 1972 to 60% in 2000.
220
221 Agricultural expansion driven by population increase, control of diseases (river blindness) and road
222 network expansion is, together with uncontrolled bush fires, the most prominent reasons for
223 reduced tree coverage in Ghana's savannah and transition zones (Wardell et al. 2003; Appiah et al.
224 2009). While conversion of off-reserve forest to palm oil, rubber and cocoa plantation is believed to
225 be the main cause of deforestation/loss of tree coverage in the high forest zone (Amanor 1996;
226 Appiah et al. 2009; Idinoba et al. 2010; Mayers et al. 2010), unsustainable timber harvest is an

227 additional factor. Based on official harvest and export volumes as well as the 1996 high forest zone
228 timber inventory, Hansen and Treue (2008) document that, over the period 1996-2005, all the
229 commercially most valuable timber species have been harvested considerably above their
230 regenerative capacity. This is particularly the case for areas outside forest reserves where the most
231 valuable timber species are almost depleted. Over-harvesting inside forest reserves may not reduce
232 the crown coverage and carbon storage as the commercially less valuable species are either not
233 harvested at all or harvested well below their regenerative capacity. However, unrecorded yet
234 sizable and seemingly accelerating illegal chainsaw lumbering is taking place within the entire high
235 forest zone, thus adding to the general depletion of forest resources (Hansen et al. 2009).
236
237 The annual deforestations rates of 0.91-1.03% for Burkina Faso in Table 2 are, thus, not in obvious
238 conflict with the available case studies. The dramatic annual deforestation rates of 1.99-2.19% for
239 Ghana might be on the high side (c.f. Hansen et al. 2009). Yet, the available case studies leave no
240 doubt that forests in the high forest, transition as well as the savannah zones are being cleared,
241 fragmented and degraded – and trees on fallow and farmlands are getting fewer and further apart.
242
243 The economic dependence of rural people on forest and non-forest environmental resources in
244 Southern Burkina Faso as well as the whole of Ghana should, therefore, be considered in a context
245 of declining forest and general tree cover. The political implications of this trend are obviously
246 compounded if the general picture of deforestation in most other West African countries (c.f. Table
247 2) share similarities with those of Burkina Faso and Ghana. This appears likely as the population
248 growth rates in these countries are either similar to or higher than those of Burkina Faso and Ghana.
249 With the exception of The Gambia and Liberia, the rural share of the population in these countries
250 is also higher or equal to that of Ghana (c.f. Table 2).

Forest and tree tenure

In Burkina Faso, the state owns all forests. Classified lands comprise 14% of the national territory and are sub-divided into classified forests, national parks and animal reserves (MECV 2004). Strict, de jure, restrictions apply to classified lands, where local peoples' use rights only include subsistence extraction of dead wood, fruits and plants for food or medicinal uses. Commercial extraction is illegal. The 1991 constitution in Burkina Faso kicked off a decentralization process which is still ongoing. According to Bouda et al. (2009), this process has two main objectives; (i) to transfer powers and resources to local governments, and (ii) to agree nationally on a standard model for rural municipalities. Many studies have, however, found that decentralization laws are ineffective and thus promote foresters' and elites' capture of control over forests (e.g. Bouda et al. 2009; Westholm and Kokko 2011) while rural populations' forest tenure rights are eroded (Sawadogo 2006; Coulibaly-Lingani 2009; Brännlund et al. 2009).

In Ghana, forest reserves cover about 11% of the national territory while national parks, wildlife sanctuaries, game and nature reserves cover about 5% (World Bank 2006). Local communities, "Stools" and "Skins", are the, de jure, owners of practically all land, but the state is the sole, de jure, manager and, de facto, owner, of forest and timber resources. Accordingly, the Forestry Commission allocates standing trees to timber companies on a concession basis (Hansen et al. 2009). Official timber rights are, however, being monopolized by integrated wood exporting companies through substantial unofficial payments while producers for the expanding domestic timber market have turned to chainsaw lumbering, which was officially banned in 1998, but in practice is allowed to continue. Rural communities in Ghana are, however, effectively restricted in

275 accessing the substantial timber revenues because their share is administratively defined as a
276 fraction (currently 50%) of the politically defined low official felling fees and because inflation
277 erodes their share due to long delays in payments (Treue 2001; FC 2009; Mayers et al. 2010;
278 Hansen and Lund 2011). Individual farmers have no rights to official timber revenues whatsoever
279 and their right to compensation for crop damages by timber companies is often violated without
280 consequences for the operators causing the damage (Marfo and Schanz 2009; Hansen 2010).
281 Without official permission, it is illegal to graze livestock inside or collect, transport and market
282 products from forest reserves (Forest Protection (Amendment) Act 2002). Yet, in practice, rural
283 people hunt, collect NTFPs and produce chainsaw lumber in forest reserves for subsistence and
284 commercial purposes without permits.
285
286 With the exceptions of Sierra Leone and Togo, all forests in West Africa are in practice government
287 owned (FAO 2010). Moreover, contrary to many countries in Eastern and Southern Africa,
288 communities have only been granted management rights to a very small fraction of government
289 forests (Sunderlin et al. 2008; FAO 2010; Ribot et al. 2010). We cannot document a causal
290 relationship between centralized forest ownership/management and deforestation/forest degradation
291 in Burkina Faso and Ghana –or other West African countries. Yet, centralized forestry
292 administrations in developing countries have generally failed to conserve their nation's forest
293 resources. This, together with the objective of improving rural livelihoods, has promoted forest
294 decentralization in a large and growing number of developing countries (Sunderlin et al. 2008).
295
296 **2.2 Data collection**
297

298 Data was collected through household surveys between November 2007 and December 2008 with a
299 total of 1014 households (279 in site 1; 257 in site 2; 244 in site 3; and 234 in site 4). Group
300 discussions were carried out at the beginning and at the end of the survey period in each of the
301 participating villages, where information about collected forest products, institutions, infrastructure,
302 trends in forest resource availability and major agricultural products was gathered. A household
303 survey was also used on a quarterly basis to collect information on households' income sources.
304 The recall period used for the income and activity reports was one month for common forest
305 products (e.g. fuelwood), environmental, small livestock (e.g. poultry), wage and business incomes.
306 A three month recall period was used for crop, larger livestock (e.g. cattle, goat, and sheep),
307 seasonal forest products (e.g. *Bombax costatum* flowers) and transfer payment incomes.
308
309 Forests "[…] is used to refer to land with a tree canopy cover of more than 10 percent and area of
310 more than 0.5 ha. [They] are determined both by the presence of trees and the absence of other
311 predominant land uses" (FAO 2000). Forest income is defined as a type of income (in cash or kind)
312 obtained from the harvesting of forest resources. Non-forest environmental income refers to the
313 cash or consumption value of collected non-forest products that are provided through natural
314 processes, which do not require intensive management.
315
316 **2.3 Data analysis**
317
318 All value estimates were obtained from respondents' own reports, which were valid and reliable
319 (Pouliot et al. 2008; Obiri et al. 2011). Total net incomes were calculated as gross values minus the
320 total costs of all purchased inputs including hired labour. To allow comparisons, all households'
321 incomes were divided by their adult equivalent units (aeu) through assigning the value 1 to the first

adult household member, 0.7 to each additional adult and 0.5 to each child (below 15 years of age) (c.f. OECD 2005). Furthermore, all values were converted to international dollars using the PPP conversion factor of 0.581 Ghanaian cedis and 248.429 CFA francs in 2008 (UNstats 2010). Based on PPP adjusted per aeu incomes, households are, by country, wealth-grouped into the 50% poorest and 50% richest (poor/better-off). Through t-tests, we tested the statistical significance of differences between means of household incomes between poor and better-off households.

3. Results

3.1 The contribution of forest and other environmental resources to rural incomes

Table 3 presents results on the contribution of different income sources to total income for poor and better-off households in Ghana and Burkina Faso. A first striking result is that non-forest environmental resources contributed very substantially to rural incomes, especially for the poorest half of households, both in Ghana (23%) and in Burkina Faso (28%). In Burkina Faso, these households' reliance on non-forest environmental income was also significantly higher than that of any other income source, while it was second to crop income in Ghana. Better-off households also relied on the non-forest environment, although to a lesser extent than poor households (on average 13% for both countries). Forest income, on the other hand, accounted for a considerably lower share of income (8-13%), and interestingly it did not vary significantly between rich and poor households, or even between countries.

Table 3 goes about here

Although our results show that rural households generated their income from many types of activities, agriculture was clearly the main source of income for both household groups in Ghana. In Burkina Faso, livestock rearing and agriculture generated an equally large share of household income. Non-farm income, including income from businesses, wage, pension, remittances and gifts, contributed 17-21% of total net household income in our sample.

3.2 Forest and non-forest environmental products

Figure 3 summarizes the importance of the most collected product categories by showing the percentage of households that collected them at least once during the recording year (bars) as well as their value (points connected with straight lines). In terms of collection frequency, fuelwood dominates with 69% of the Ghanaian and 74% of the Burkinabe households collecting it at least once a year in the forest while 98% of the Ghanaian and 89% of Burkinabe households collected fuelwood in the environment outside forests. Collection of wild foods (e.g. nuts, fruits, leaves) was also a common activity, especially in Burkina Faso where 50% of the households collected these at least once from the forest and 97% from the non-forest environment. In Ghana, 41% of the households collected wild foods in the forest while 86% did it in the non-forest environment. Medicinal plants and fodder (site 1) were also commonly collected in Burkina Faso and bushmeat was frequently reported by Ghanaian households.

The product categories which, on average, generated the highest total income for collecting households in site 1 were: (i) wild foods, fodder and thatching grass for better-off households, and (ii) wild foods, thatching grass and fuelwood for poor households. In site 2, the products which generated highest income were: (i) wild foods, fuelwood and medicinal plants for better-off

households, and (ii) wild foods, fuelwood and bushmeat for poor households. In sites 3 and 4, those products were: (i) bushmeat, timber and construction materials for better-off households, and (ii) bushmeat, fuelwood, thatching grass (site 3) and timber (site 4) for poorer households.

Figure 3 goes about here

Moreover, livestock was often reported to browse and graze in forest areas of Burkina Faso. In total, 178 or 33% of the 536 households reported sending livestock to the forest, at least during some parts of the year and especially during the agricultural season. During that period, 128 households reported sending their livestock to graze in the forest for, on average, 64% of the time. No browsing and grazing in forests was reported by the Ghanaian households.

Figure 3 also shows households' reliance on the non-forest environment vs. forests for each product category. The pattern is that *all* product categories are collected both in forests and the non-forest environment but *most* are collected more often in the non-forest environment by the poor *and* the better-off households. A few products were collected as often in forests as in the non-forest environment (e.g. thatching grass by better-off households in site 1) and only in one of the four sites a product category was collected more often inside than outside forests (poles and timber by both poor and better-off households in site 4).

Average per aeu incomes are generally higher for better-off than poor households, for all product categories. Furthermore, income from most product categories seem unrelated to their origin (i.e. forest vs. non-forest environment as solid and broken green/red lines generally lie close to each other). Yet, (i) in Burkina Faso, all households generated much higher wild food revenues from the

non-forest environment than from forests, (ii) in site 3, better-off households generated much higher bushmeat revenues from forests than from the non-forest environment and (iii) poles and timber from the forests in site 4, generated particularly high revenues for better-off households.

4. Discussion

Importance of forest and non-forest environmental incomes

Although the rural households in Ghana generated considerably higher absolute income than the rural households in Burkina Faso, the relative economic importance of forests and non-forest environmental resources are strikingly similar across countries. The general pattern being that, in combination, forest and non-forest environmental incomes account for more than a third of the poorest households' annual income (36% in Ghana and Burkina Faso; Table 3) while contributing as much as 23% to the better-off households' income. This echoes other studies which document that, in developing countries, all rural households and particularly the poorest depend considerably on non-cultivated and, hence, semi-open access resources for their livelihoods (e.g. Cavendish 2000; Vedeld et al. 2004; Mamo et al. 2007 Kamanga et al. 2009). It is, however, remarkable that in both Burkina Faso and Ghana, the poorest households depend much more on the non-forest environment than on forests, which contradicts that forests are particularly important for the rural poor. Whether this is a result of poor people's access to forests being socially more restricted or whether the most collected products, e.g. fuelwood and wild foods, are simply more plentiful and physically easier to access outside than inside forests is not possible to say based on this study's data -except in the case of wild foods in Burkina Faso where one of the dominant products, shea

418 nuts, is almost exclusively collected outside forests because of its abundance in agroforestry
419 parklands (Breman and Kessler 1995).
420
421 *Livelihood consequences of forest degradation in West Africa*
422
423 The significant economic importance of forest and non-forest environmental products to rural
424 people raises concern over the social consequences of deforestation and forest degradation (e.g. de
425 Sherbinin et al. 2008; Shackleton et al. 2011). Moreover, if population growth and Sahelian
426 people's adaptation to climate change by migrating southwards lead to the observed loss of tree
427 coverage in West Africa, then the predicted social problems are likely to materialize very soon in
428 this part of the world. This scenario is, however, conditional on the degree to which rural people
429 actually depend on forests and whether they are capable of adapting to an environment with less
430 and smaller forests (c.f. similarities with the fuelwood crises predicted in the 1970s, e.g. Vermeulen
431 2001). Ideally, panel data should be used to document such trade-offs, but the observed pattern of
432 product collection in forests and the non-forest environment provides useful insight as they reflect
433 the sum of individuals' decisions on what pays to collect where, given the, de facto, accessibility of
434 forest and non-forest environmental resources that the governance system, demographic
435 development and changes in land cover types have shaped.
436
437 Figure 3 may therefore be interpreted to illustrate that, in the likely event of more forests being
438 converted into e.g. woodlands, very few important products are liable to become critically scarce
439 simply because most products collected in forests are also collected in the non-forest environment.
440 Two important exceptions are timber and bushmeat in Ghana. When collected in forests, these
441 products generated very high incomes, but only to better-off households. Moreover, since products

from the non-forest environment are in total more valuable to rural people in general and the poorest in particular (Table 3), then an average area of land converted from forest to agriculture and non-forest land types (e.g. parklands, woodlands, fallows and bush lands) actually increases the value of such land *to rural people*. Accordingly, during the process of agricultural expansion and what scholars and environmentalists tend to label forest 'degradation', we cannot expect rural people to conserve forests because they are of particularly high value to them, on the contrary, in fact.

This general and historically well know picture across the world of poor people adding value to land for themselves by removing trees is, however, not entirely straight forward. In absolute terms, the richest households in Ghana extract around five times more value from forests than the poorest (Table 3). This is because, in comparison to the poorest households, they generate much higher absolute incomes from the categories "bushmeat" and "poles and timber", which are not nearly as prominent in the non-forest environment where bushmeat is also sourced in substantial amounts (Figure 3). Pastoralists in Burkina Faso might also suffer if they end up with a shrinking area to graze their cattle during the cropping season. Yet, unless the reserved forests are encroached by permanent agriculture and associated settlements, these areas might still be available for cattle browsing irrespective of a declining tree cover. A gradual replacement of unreserved forest by agriculture will, however, decrease the total area of cropping season 'cattle stations'.

These considerations assume that converted forests add to the stock of non-forest environmental areas, which is of course not necessarily the case if, as the land cover change analyses document, the area under agriculture is expanded. However, as Table 3 indicates, cropland seems, not surprisingly, to be the most valuable land use to rural people *except for the poorest half of*

Burkinabe households. Accordingly, the poorest *might* end up as losers *if* forests are converted to more open land types while even more of the non-forest environment is captured for cultivation *by better-off households*. This is, however, not (yet) the situation because, over the past 20-30 years, the areas of agriculture *as well as* the areas of more or less open wood lands seem to have increased (c.f. the above quoted land cover change studies).

In sum, the bottom line appears to be that forests do provide important environmental products to rural people but their option value as land banks are in fact much higher when migration (possibly climate change induced) and the general population increase as well as infrastructural developments make remote areas more accessible thus enhancing the demand pressure for cropland. Accordingly, if rich countries should transfer funds to poor West African countries in an effort to mitigate climate change through REDD+, then it needs to be associated with making forests more valuable to rural people *as forests*. This would, however, require radical reform of land and forest tenure such that rural people may get tangible and legally enforceable rights to REDD+ revenues. Otherwise, REDD+ may well repeat the development in Ghana's high forest zone where the political and the timber elites, through their control over timber rights and harvesting fees, capture the biggest forest revenues but gradually lose control over the forest area and timber resources, both of which are dwindling. In other words, REDD+ payments to 'save' some of the remaining forest resources in Burkina Faso and Ghana will in all likelihood fail in the absence of radical reform of forest rights. The central states may obviously control REDD+ revenue flows but these will be performance-based and are thus unlikely to ever materialize unless new forest governance approaches replace the current and, in terms of forest conservation, rather unsuccessful forest governance systems (c.f. above). This aspect of REDD+ is, however, not particularly prominent in the ongoing processes

where Burkina Faso and Ghana happen to be pilot REDD+ countries (Mayers et al. 2010;Westholm and Kokko 2011).

5. Conclusion

Environmental resources, and especially non-forest resources, were shown to be a major source of income for rural households in Burkina Faso and Ghana. Together, forest and non-forest environmental resources represent 36% and 23% of total income for the poorest and better-off households, respectively, in Burkina Faso and Ghana. In the likely event that agriculture and non-forest land types continue to replace forests, rural people would not lose much and many might actually gain because, in comparison to forests, rural people generally derive higher or equally high values from cropping and from the non-forest environment. This is in part due to rural people's restricted access to the most valuable forest resources (timber in particular). Better-off households relying on timber and/or bushmeat in Ghana could however be affected negatively due to the apparent low availability of these resources in the non-forest environment. Moreover, forest degradation could have a negative impact on Burkinabe cattle herders who use forests as seasonal grazing reservoirs.

Accordingly, if West African forests should be conserved e.g. to mitigate climate change though REDD+ schemes, they must be made more valuable to rural people as forests -not as land banks. This can only be achieved through a combination of sufficiently high REDD+ payments and a reform of forest rights and revenues, which will ensure that local people favor forest conservation over other land uses.

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521 **References**

522

523 Amanor, K.S. 1996. Managing trees in the farming system: The perspectives of farmers. Forestry
524 Department, Accra, Ghana, 202 pp.
525 Appiah, M., D. Blay, L. Damnyag, F. K. Dwomoh, A. Pappinen, and O. Luukkanen. 2009.
526 Dependence on forest resources and tropical deforestation in Ghana. *Environment,*
527 *Development and Sustainability* 11: 471-487.
528 Bicheron, P., P. Defourny, C. Brockmann, L. Schouten, C. Vancutsem, M. Huc, S. Bontemps, M.
529 Leroy, et al. 2008. GLOBCOVER 2008: Products Desctription and Validation Report.
530 Retrieved September 21st, 2011, from http://ionia1.esrin.esa.int/.
531 Bontemps, S., P. Defourny, E. Van Bogaert, O. Arino, V. Kalogirou, and J. R. Perez. 2011.
532 GLOBCOVER 2009: Products Description and Validaiton Report. European Space Agency.
533 Retrieved September 21st, 2011, from
534 http://ionia1.esrin.esa.int/docs/GLOBCOVER2009_Validation_Report_2.2.pdf.
535 Bouda, H. N., P. Savadogo, D. Tiveau, and B. Ouedraogo. 2009. State, forest and community:
536 challenges of democratically decentralizing forest management in the centre-west region of
537 Burkina Faso. *Sustainable development* 19: 275-288.
538 Brännlund, R., A. Sidibe, and P. Gong. 2009. Participation to forest conservation in National
539 Kabore Tambi Park in Southern Burkina Faso. *Forest Policy and Economics* 11: 468-474.
540 Breman, H., and J. J. Kessler. 1995. *Woody plants in agro-ecosystems of semi-arid regions, with an*
541 *emphasis on the Sahelian countries*. Berlin: Springer Verlag.
542 Cavendish, W. 2000. Empirical regularities in the poverty-environment relationships of rural
543 households: evidence from Zimbabwe. *World Development* 28(11): 1979-2003.

544 Coulibaly-Lingani, P., M. Tigabu, P. Savadogo, P.-C. Oden, and J.-M. Ouadba. 2009. Determinants
545 of access to forest products in southern Burkina Faso. *Forest Policy and Economics* 11(7):
546 516-524.
547 de Sherbinin, A., L. K. VanWey, K. McSweeney, R. Aggarwal, A. Barbieri, S. Henry, L. M.
548 Hunter, W. Twine, and R. Walker. 2008. Rural household demographics, livelihoods and the
549 environment. *Global Environmental Change* 18: 38-53.
550 ESA/GLOBCOVER 2008. European Space Agency Ionia GlobCover Portal. Retrieved September
551 21st, 2011, from http://ionia1.esrin.esa.int/.
552 FAO. 2010. Forest Resource Assessment 2010. Retrieved September 14th, 2011, from
553 http://www.fao.org/docrep/013/i1757e/i1757e.pdf.
554 FAO. 2008. FAOSTAT. Retrieved September 14th, 2011, from
555 http://faostat.fao.org/site/550/default.aspx#ancor.
556 FAO. 2000. FRA 2000 on definitions of forest and forest change. Retrieved September 14th, 2011,
557 from http://www.fao.org/docrep/006/ad665e/ad665e00.htm#TopOfPage.
558 FC. 2009. Office of the administrator of stool lands & forestry commission stumpage/rent
559 disbursement report for 1st January 2009 – 30th June, 2009. Retrieved September 7th, 2011,
560 from www.fcghana.com/publications/forestry_issues/stumpage_jan_jun_2009/index.htm.
561 Gakou, M., J. E. Force,and W. J. McLaughlin. 1994. Non-timber forest products in rural Mali: a
562 study of villager use. *Agroforestry Systems* 28: 213-226.
563 Gonzalez, P. 2001. Desertification and a shift of forest species in the West African Sahel. *Climate*
564 *Research* 17: 217-228.
565 Hansen, C.P. 2010. Forest law compliance and enforcement: the case of on-farm timber extraction
566 in Ghana. *Journal of Environmental Management* 92(3): 575-586.

567 Hansen, C.P. and J. F. Lund. 2011. The political economy of timber taxation: The case of Ghana.
568 *Forest Policy and Economics* 13(8): 630-641.
569 Hansen, C.P., and T. Treue. 2008. Assessing illegal logging in Ghana. *International Forestry*
570 *Review* 10(4): 573-590.
571 Hansen, C.P., J. F. Lund, and T. Treue. 2009. Neither fast, nor easy: the prospects of Reducing
572 Emissions from Deforestation and Degradation (REDD) in Ghana. *International Forestry*
573 *Review* 11(4): 439-455.
574 Harris, F., and M. Salisu. 2003. Relying on Nature: Wild Foods in Northern Nigeria. *Ambio* 32 (1):
575 24-29.
576 Henry, S., V. Piché, D. Ouédraogo, and E. F. Lambin. 2004a. Descriptive analysis of the individual
577 migratory pathways according to environmental typologies. *Population and Environment*
578 25(5): 397-422.
579 Henry, S., B. Schoumaker, and C. Beauchemin. 2004b. The impact of rainfall on the first out-
580 migration: a multi-level event-history analysis in Burkina Faso. *Population and Environment*
581 25(5): 423-460.
582 Idinoba, M., J. Nkem, F. B. Kalame, E. Tachie-Obeng, and B. Gyampoh. 2010. Dealing with
583 reducing trends in forest ecosystem services through a vulnerability assessment and planned
584 adaptation actions. *African Journal of Science and Technology* 4(7), pp. 419-429.
585 IPCC. 2007. Fourth assessment report: Working group two, impacts, adaptation and vulnerability:
586 Summary for policy makers. Intergovernmental panel on climate change. Retrieved June 6th,
587 2011, from http://www.ipcc.ch/publications_and_data/ar4/wg2/en/spm.html.
588 Kamanga, P., P. Vedeld, and E. Sjaastad. 2009. Forest incomes and rural livelihoods in Chiradzulu
589 District, Malawi. *Ecological Economics* 68(3): 613-624.

590 Mamo, G., E. Sjaastad, and P. Vedeld. 2007. Economic dependence on forest resources: A case
591 from Dendi District, Ethiopia. *Forest Policy and Economics* 9: 916-927.
592 Marfo, E., and H. Schanz. 2009. Managing logging compensation payment conflicts in Ghana:
593 Understanding actor-empowerment and implications for policy intervention. *Land Use Policy*
594 26(3): 619-629.
595 Mayers, J., S. Maginnis, and E. Arthur. 2010. REDD Readiness Requires Radical Reform:
596 Prospects for making the big changes needed to prepare for REDD-plus in Ghana. The Forest
597 Dialogue (TFD). Retrieved September 7th, 2011, from http://www.theforestdialogue.org.
598 MECV. 2004. Cadre stratégique de lutte contre la pauvreté. Ministère de l'environnement et du
599 Cadre de vie. Retrieved February 1st, 2011, from http://www.pnud.bf/docs/CSLP.PDF.
600 Obiri, B.D., E. Marfo, E. Nutakor, J. Cobbinah, and T. Treue. 2011. Estimating rural forest
601 dependency in Ghana: Contextual information, methods and preliminary results. Forest and
602 Landscape Working paper no. 64, Copenhagen, Denmark, 95 pp.
603 OECD. 2005. What are equivalence scales? Retrieved November 15th, 2011, from
604 http://www.oecd.org/dataoecd/61/52/35411111.pdf.
605 Ouedraogo, I., M. Tigabu, P. Savadogo, H. Compaoré, P. C. Odén, and J. M. Ouadba. 2010. Land
606 cover change and its relation with population dynamics in Burkina Faso, West Africa. *Land*
607 *Degradation and Development* 21: 453-462.
608 Ouedraogo, I., P. Savadogo, M. Tigabu, R. Cole, P. C. Odén, and J. M. Ouadba. 2009. Is rural
609 migration a threat to environmental sustainability in southern Burkina Faso? *Land*
610 *degradation and development* 20: 217-230.
611 Pouliot, M., B. Ouedraogo, C. Smith-Hall, and H. L. Simonsen. 2008. Household-level studies of
612 forests and poverty in Burkina Faso: Contextual information, methods and preliminary results.
613 Forest and Landscape Working paper no. 47, Copenhagen, Denmark, 92 pp.

614 Ribot, J.C., J. F. Lund, and T. Treue. 2010. Democratic decentralization in sub-Saharan Africa: its
615 contribution to forest management, livelihoods and enfranchisement. *Environmental*
616 *Conservation* 37(1) : 35-44.
617 Sawadogo, L. 2006. Adapter les approches de l'aménagement durable des forêts sèches aux
618 aptitutes sociales, économiques et technologiques en Afrique: le cas du Burkina Faso.
619 Retrieved June 6th, 2011, from
620 http://www.cifor.cgiar.org/publications/pdf_files/Books/BSawadogo0601.pdf.
621 Shackleton, C. M., S. E. Shackleton, and P. Shanley. 2011. Building a Holistic Picture: An
622 Integrative Analysis of Current and Future Prospects for Non-timber Forest Products in a
623 Changing World. In *Non-timber forest products in the global context*, ed. Shackleton, C. M.,
624 S. E. Shackleton, and P. Shanley. Berlin: Springer-Verlag.
625 Shackleton, CM., S. E. Shackleton, E. Buiten, and N. Bird. 2007. The importance of dry woodlands
626 and forests in rural livelihoods and poverty alleviation in South Africa. *Forest Policy and*
627 *Economics* 9: 558-77.
628 Sunderlin, W., J. Hatcher, and M. Liddle. 2008. From exclusion to ownership? Challenges and
629 opportunities in advancing forest tenure reform. Rights and Resources Initiative, Washington
630 D.C., USA, 54 pp.
631 Treue, T. 2001. *Politics and economics of tropical high forest management: A case study of Ghana*.
632 Dordrecht: Klüver Academic Publishers.
633 UNDP. 2011. Human Development Report 2011: Sustainability and equity: A better future for all.
634 United Nations Development Programme. Retrieved November 15th, 2011, from
635 http://hdr.undp.org/en/media/HDR_2011_EN_Complete.pdf.

636 UNstats. 2010. Purchasing power parities (PPP) conversion factor, local currency unit to
637 international dollar. Retrieved May 26th, 2011, from
638 http://unstats.un.org/unsd/mdg/SeriesDetail.aspx?srid=699.
639 Vermeulen, S. 2001. Woodfuel in Africa: crisis or adaptation? Literature review. Retrieved
640 December 13th, 2011, from
641 http://130.241.192.19/Files/nationalekonomi/eeu/publications/cifor/chapter6.pdf.
642 Vedeld, P., A. Angelsen, E. Sjaastad, and G. K. Berg. 2004. Counting on the environment: forest
643 incomes and the rural poor. The World Bank Environmental Department, Environmental
644 economics series 98, Washington D.C., USA, 95 pp.
645 Wardell, D.A., A. Reenberg, and C. Tøttrup. 2003. Historical footprints in contemporary land use
646 systems: forest cover changes in savannah woodlands in the Sudano-Sahelian zone. *Global*
647 *Environmental Change* 13: 235-254.
648 Westholm, L., and S. Kokko. 2011. Prospects for REDD+: Local forest management and climate
649 change mitigation in Burkina Faso. Retrieved May 27th, 2011, from
650 http://www.focali.se/en/articles/artikelarkiv/prospects-for-redd-local-forest-management-and-
651 climate-change-mitigation-in-burkina-faso.
652 Whiteman, A. and A. Lebedys. 2006. The contribution of the forestry sector to African economies.
653 *International Forestry Review* 8(1): 31-43.
654 World Bank. 2006. Ghana country environmental analysis. Report No: 36985-GH. Environmentally
655 and socially sustainable development department (AFTSD) Africa region. Retrieved November
656 15th, 2011, from http://siteresources.worldbank.org/INTRANETENVIRONMENT/3635842-
657 1175696087492/21919456/Ghana_CEA.pdf.
658

659 Figure 1 Land cover types of West Africa (Bicheron et al. 2008 and ESA/GLOBCOVER 2008)

660

661 Figure 2 Location of sites 1-4 within West African land cover types

662

663 Figure 3 Percentage of households collecting (bars referring to the left hand side y-axis) and
664 average income per adult equivalent unit by collecting households (lines referring to the right hand
665 side y-axis), by household and product categories, sites1-4.

666

667 Table 1 Legend to Figures 1-2 and percentage of land cover types
668

Colour	Land cover type	% of land cover in Figure 1*
	Bare areas	2.6
	Sparse vegetation (woody vegetation, scrubs, grassland)	1.0
	Closed to open (>15%) grassland	7.1
	Regularly flooded	0.2
	Unclassified	6.4
	Sparse herbaceous vegetation and grassland	7.6
	Rainfed croplands	15.9
	Mosaic: (Grassland, scrubland, forest) (50-70%) / Cropland (20-50%)	11.4
	Closed to open (>15%) scrubland (<5m)	20.3
	Mosaic: Grassland (50-70%) / Forest/ Scrubland (20-50%)	1.2
	Mosaic: Forest/Scubland (50-70%)/Grassland (20-50%)	4.9
	Mosaic: Cropland, Tree cover and Natural Vegetation	13.8
	Closed to open (>15%) evergreen and/semi-deciduous forest (>5m)	6.7
	Closed (>40%) broadleaved forest regularly flooded - Fresh water	0.2
	Closed (>40%) broadleaved semi-deciduous and/or evergreen forest regularly flooded - Saline water	0.6
	Water bodies	NA
	Urban areas	0.1
	TOTAL	100.0

669 Source: Bontemps et al. 2011
670 *Calculated as the relative numbers of non-water body pixels in figure 1
671

672 Table 2 Trends in population (2008) and extent of forest area 1990-2010
673

Country	Population 2008				Forest area (1000 ha)				Annual change rate (%[a])		
	Total (1000)	Density (Population/ km2)	Annual growth rate	Rural population (% of total)	1990	2000	2005	2010	1990-2000	2000-2005	2005-2010
Benin	8662	78	3.2	59	5761	5061	4811	4561	-1.29	-1.01	-1.06
Burkina Faso	15234	56	3.5	81	6847	6248	5949	5649	-0.91	-0.98	-1.03
Côte d'Ivoire	20591	65	2.3	51	10222	10328	10405	10403	0.10	0.15	n.s.
Gambia	1660	166	2.7	44	442	461	471	480	0.42	0.43	0.38
Ghana	23351	103	2.1	50	7448	6094	5517	4940	-1.99	-1.97	-2.19
Guinea	9833	40	2.3	66	7264	6904	6724	6544	-0.51	-0.53	-0.54
Guinea-Bissau	1575	56	2.2	70	2216	2120	2072	2022	-0.44	-0.46	-0.49
Liberia	3793	39	4.6	40	4929	4629	4479	4329	-0.63	-0.66	-0.68
Mali	12706	10	2.4	68	14072	13281	12885	12490	-0.58	-0.60	-0.62
Niger	14704	12	4.0	84	1945	1328	1266	1204	-3.74	-0.95	-1.00
Nigeria	151212	166	2.4	52	17234	13137	11089	9041	-2.68	-3.33	-4.00
Senegal	12211	63	2.7	58	9348	8898	8673	8473	-0.49	-0.51	-0.47
Sierra Leone	5560	78	2.6	62	3118	2922	2824	2726	-0.65	-0.68	-0.70
Togo	6459	119	2.5	58	685	486	386	287	-3.37	-4.50	-5.75

674 [a] Rate of gain or loss in percent of the remaining forest area each year within the given period.
675 Source: FAOSTAT (FAO, 2008) and FRA 2010 (FAO, 2010).
676
677 Table 3 Total annual income by sources and income group
678

	Income groups, Ghana		P-value (t-test)	Income groups, Burkina Faso		P-value (t-test)
	Poor (n=227)	Better-off (n=239)		Poor (n=262)	Better-off (n=268)	
Total net income ($(PPP adjusted) per aeu)	462	3014	0.0000	211	1054	0.0000
Crop share	0.33	0.53	0.0000	0.22	0.29	0.0001
Livestock share	0.10	0.07	0.0184	0.23	0.29	0.0033
Non-forest environmental share	0.23	0.13	0.0001	0.28	0.13	0.0000
Forest share	0.13	0.10	0.1067	0.08	0.10	0.9136
Non-farm income share	0.21	0.17	0.1431	0.19	0.19	0.2703

679 Households with negative net yearly income (n=12 for Ghana and n=6 for Burkina Faso) were not
680 included in this analysis. Negative household income was due to e.g. crop failure, loss of livestock,
681 etc.
682 To reduce the influence of extreme individual household values, income shares are here calculated
683 as the means of individual household's shares for each group of income sources (instead of the

684 share of aggregated income by sources in aggregated total income across all households within each
685 income group).

Figure 1
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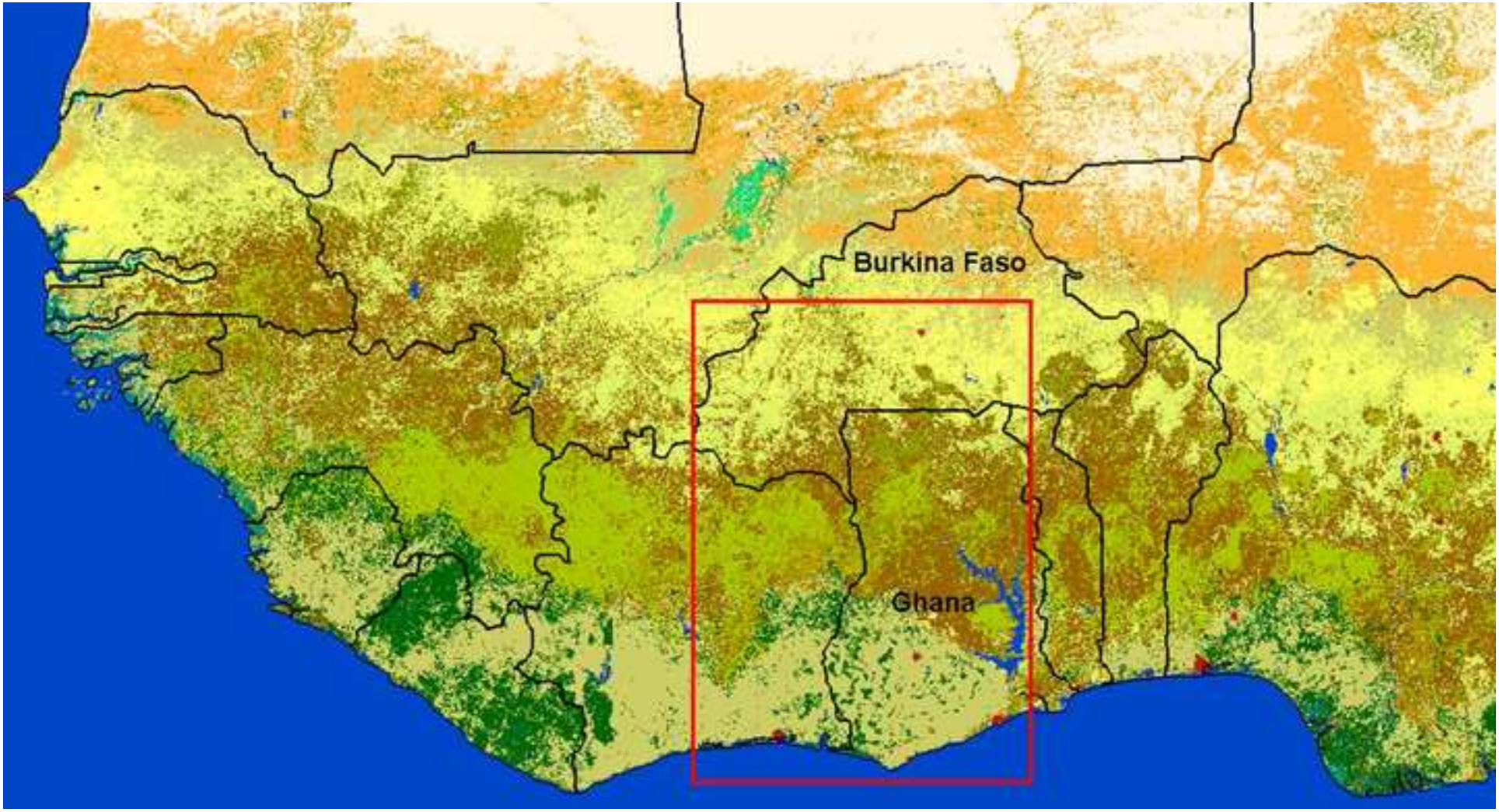

Figure 2
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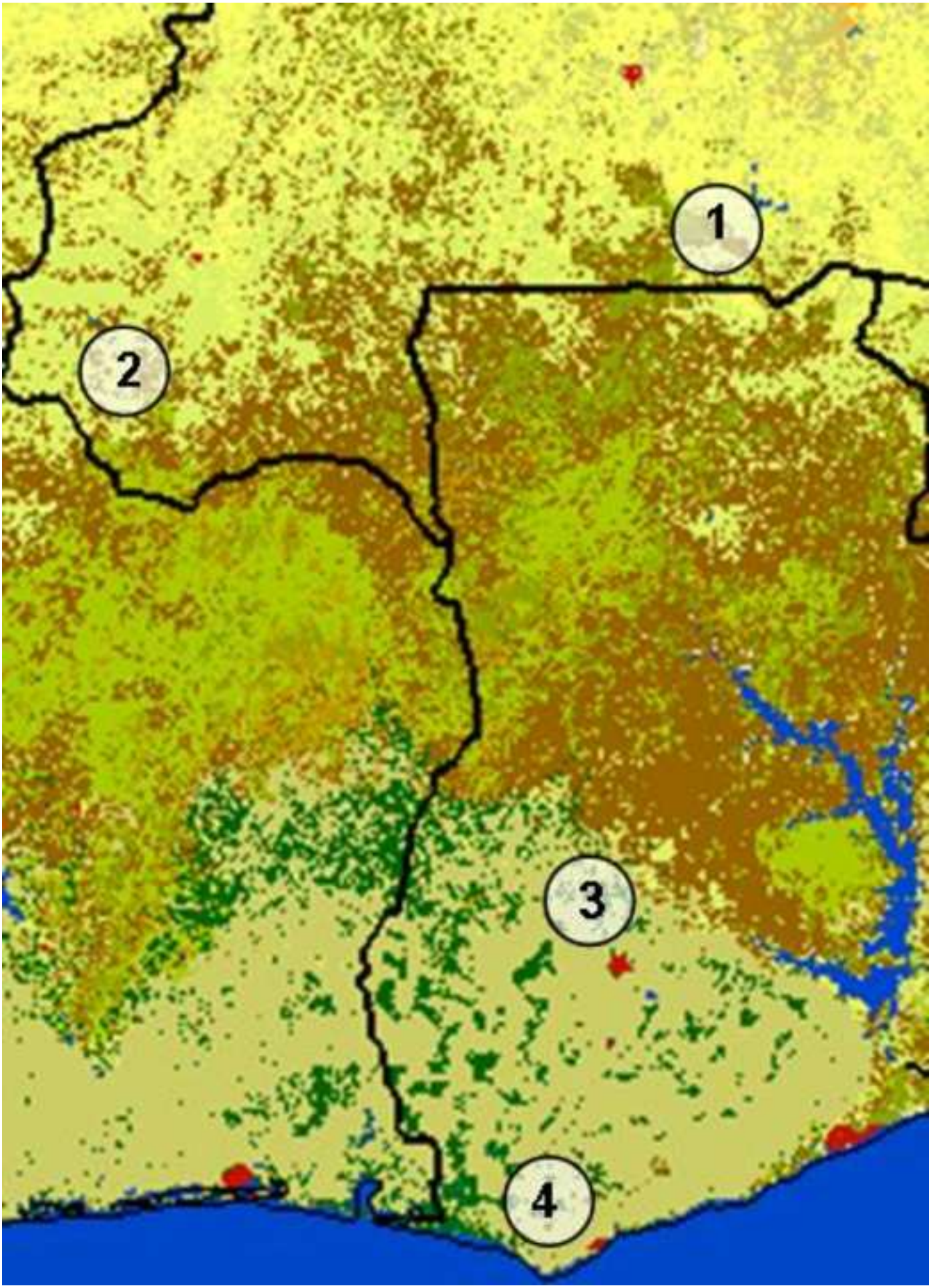

Figure 3
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